The Radio Beam Method of Transmission

By LIEUT. H. F. BRECKEL

THE history of the so-called "Radio Beam" system, now being employed by the British station located in southwest Cornwall for directional communication with Canada, dates back almost to the very inception of the art of wireless telegraphy. In fact, the modern application of this directive method of radio transmission may be quite properly termed a reappearance of an early-discovered phenomenon; which was never applied commercially, because of the lack of efficient equipment, or other practical drawbacks.

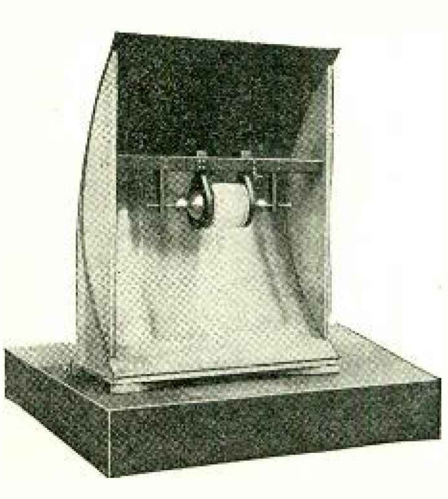
EARLY RESEARCHES

It is a matter of record that the German professor, Rudolf Heinrich Hertz, employed the beam or directive system of radio transmission as early as 1888; when he utilized a system of parabolic reflectors (see Fig. 3) which concentrated, into a narrow directional beam, waves in the order of only thirty centimeters in length.

It is also recorded in the British patent application of Guglielmo Marconi (dated June 2, 1896) that he utilized a wavelength of only ten inches in experiments incidental to the development of the beam system of radio transmission. It is also recorded in the same patent, with specific relation to the beam system, that: "When it is desired that the signal should only be sent in one direction, the oscillation producer is placed in the focus or focal line of a reflector, comprising a metallic sheet of brass or copper shaped to a parabolic form. (See Fig. 3.) This reflector is then directed towards the receiving station, which comprises a concave reflector with the receiver proper mounted in such position as to intercept the reflected ring of radiations which exists behind or before the focus of the reflector; and the receiver ought to be preferably tuned with the length of wave of the oscillation transmitted."

PERIOD OF DEVELOPMENT

Thus we see that the basic principles of the so-called modern radio beam method, as well as the now generally-used short waves, are old; both having been utilized by the earliest proponents of the art of radio. However, it is only proper to state that the development, leading eventually to commercial use of the combination of the two basic ideas, progressed steadily, if slowly, over the years intervening. The recorded achievements of Marconi, as well as the conceptions of other noted radio inventors, in the field of directional radio transmission (among them being DeForest, Brown, Franklin, Braun and others) serve to exemplify the important benefits they believed would result from the commercial or military application of such a system.



This picture shows a very early model transmitter, invented by Marconi for short-wave beam-radio work.

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Judging from results obtained and from records available, Marconi pursued his search for perfection and practical application aggressively and, ultimately, was successful. It is reported that he was successful, as early as 1907, in carrying out radio beam transmission between his station in Cornwall, England, and a squadron of naval vessels at anchor off Gibraltar in the Mediterranean; communication with one of the vessels being carried on without her consorts (although close at hand) being aware of it, the signals from Cornwall being focused in a narrow beam over the intervening miles upon the vessel's receptor device.

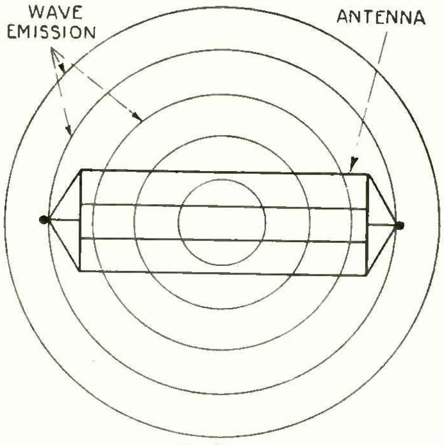


FIG. 1

The wave emission from an ordinary flat-top transmitting antenna. It spreads out in all directions, almost equally.

This feature would seem to possess certain strategical advantages to a naval force in the way of promoting secrecy and minimizing interference to its communications under certain conditions; such as attempted "jamming" on the part of an enemy force.

In the year 1923 Marconi predicted that "the radio beam system would bring about a somewhat revolutionary change from ordinary long-wave methods hitherto employed for radio communication between distant countries," this prediction being based apparently, on the practical advantages afforded through the utilization of such a system. Briefly considered these are:

HIGHER EFFICIENCY

(1) The reduction of interference, whether direct or set up by harmonics, between stations; thus making it possible to operate in a given band of frequencies a greater number of stations. This is accomplished through propagation of the wave forces to their destination in a narrow beam rather than allowing them to spread out in all directions as with the ordinary method of radio transmission.

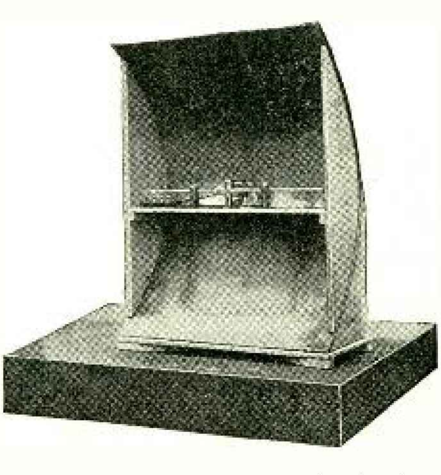
(2) Greater economy in power consumption for a given distance, due to more effective utilization of the oscillatory energy, through the method of focusing the major portion of it in the desired direction.

(3) Due to the comparatively narrow zone traversed by the signals, the reception thereof is limited to such receptor stations as are located immediately in the plane of the propagation; thus affording an element of secrecy and privacy to the communicated intelligence. This is further augmented by the extremely high speed of transmission; which, being in the neighborhood of 200 words or more per minute, makes it practically impossible to copy the communicated intelligence except through the medium of elaborate, automatic recording apparatus.

(4) Owing to the use of short waves by the system, it possesses the additional advantages of higher possible speed of transmission and reception, as compared to the ordinary methods employed for long-distance communication; as well as higher audibility of signal values at the receptor end for a given power input. Further, due to the greater volume of signal strength and the minimized interference due to atmospherics or static, communication can be maintained virtually without interruption. Traffic is thus speeded up, there being no reason for "repeats" or ceasing communication entirely until the atmosphere clears, so frequently the case where the ordinary systems are employed.

COMPARISON WITH BROADCAST METHODS

In effecting an elementary comparison of the broadcast system of radio transmission to the beam system, the former may be best illustrated by the ripples or waves formed on the surface of a pool of water when a stone is thrown into it. These travel over the entire area of a circle. In the case of a radio transmitter, the original energy contained in the antenna system is widely disseminated throughout space, only a very minor portion reaching any one particular reception point. The efficiency factor of such a system is very low, especially when it is desired to effect communication with only one point; whereas energy is propagated in all directions. This objection does not, of course, apply to broadcast stations or others desiring to reach the greatest number of receiving points for a given transmission.



Marconi's early model receiver for focusing the signals from beam transmission, designed by him in 1895.

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In the radio beam system, however, the principle of propagation is different, in that the energy generated in the antenna system is concentrated and focused into a beam. This can be likened to the ray of a searchlight which concentrates all of the light emanating from a given source and propagates it in a given direction only. This focusing of the radio energy into a narrow beam of some 15° width results in an intensive propagation directly toward the receiving station with which it is desired to communicate, little or none taking place in other directions.

The efficiency factor of such a system is at once apparent and it is only necessary to mention that the strength of signals received from a beam transmitter is computed to be some 24 times greater than that from the ordinary type of radio transmitter utilizing the same power input and wavelength and operating under the same atmospheric conditions.

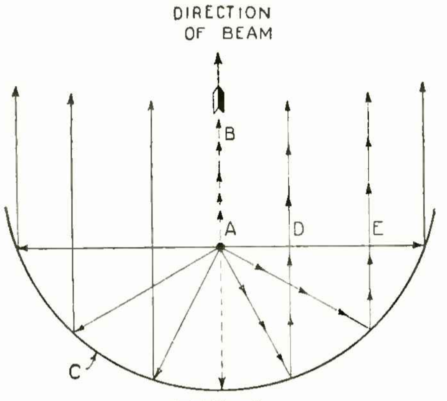

FIG. 3

A is the focus of the reflector, C. The waves starting at A are reflected parallel to A-B, as indicated at D and E, thus being concentrated into a narrow beam.

TYPES OF ANTENNA

The essential difference between the broadcast and the radio beam methods lies merely in the antenna systems employed. The ordinary type of antenna normally employed is shown in Fig. 1; and functions, generally speaking, as set forth in the "stone and water" analogy.

The radio beam antenna system is shown in Fig. 2, and differs essentially from the ordinary type, as can be at once perceived. It comprises two distinct networks of vertically-suspended wires; one possessing the larger number of vertical units and being termed technically the "reflector," while the other has half as many vertical wires and is called the "radiator" or aerial.

The two units comprising the whole antenna system are spaced a quarter-wavelength apart, by the horizontal cross-arms of the T-type masts employed for suspending them. Both the radiator and reflector wires are hung vertically from insulated horizontal wires, being sustained at even tension against swaying, etc., by means of a system of weights and balances. In the particular system employed by the British station at Bodmin (Cornwall) and the Canadian station at Yamachiche, it is recorded that some 32 wires are used for the radiating section of the transmitting antenna; each of these being divided into four half-wave sections connected through special inductances.

The reflector section is suspended in the rear of the radiating section, opposite to the desired direction of propagation, as also shown in Fig. 2. Each of the four tuned radiating sections comprising the unit is energized by means of feeders, of such inductive and capacitive values as to provide the proper degree of resonance between the various sections comprising the whole. The source of energy is in the form of a conventional vacuum-tube transmitter of the master oscillator-power amplifier type, of some twenty thousand watts power.

In regard to the functioning of the antenna system, it may be stated that the wave emission proceeds forward in the normal direction to be expected where a vertical antenna is utilized, as well as in the opposite direction. However, this rearward component of the emitted wave, instead of being allowed to dissipate itself by radiation to all points of the compass, is restrained or blocked from so doing by the network of reflector wires suspended in the rear of the radiating wires. The rearward component of the wave emission, upon encountering this reflector system, is deflected or re-radiated forward, opposite to its original direction, in the desired direction of propagation; thus re-enforcing the forward component of the wave emitted by the radiating system proper. This action is also depicted in Fig. 2.

RECEIVING REFLECTORS

For the reception of the transmitted radio beam, an antenna system of practically similar design is employed as the collector for the receiving apparatus. It is so located that the wires which correspond to the "radiating" section of the transmitter, and now become the "collector section" for actuating the receiver, face the plane of propagation of the beam emanating from the transmitter. In the rear of this collector section is suspended the reflector section, identical in construction to that employed for the transmitting antenna. The latter acts in much the same manner on the received energy; *i.e.*, it intercepts an additional amount of energy from the propagated wave-front, reflecting it forward to the main collector section, where it greatly augments the signal strength.

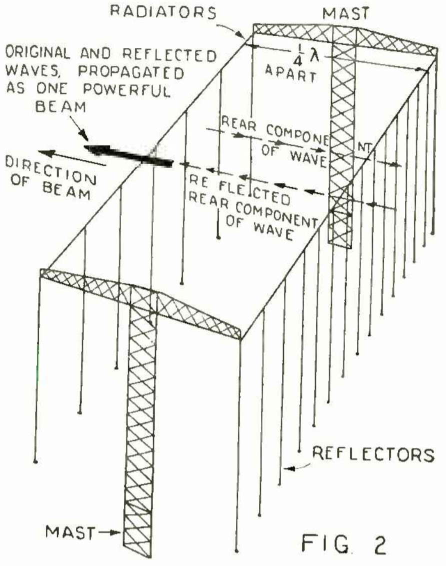
RADIATORS
MAST
ORIGINAL AND REFLECTED WAVES, PROPAGATED AS ONE POWERFUL BEAM
1/4 λ APART
REAR COMPONENT OF WAVE
DIRECTION OF BEAM
REFLECTED REAR COMPONENT OF WAVE
REFLECTORS
MAST

FIG. 2

How the antenna system of a beam transmitter functions may be seen above.

It has been stated that the energy collected at the receptor, by such an antenna system, is theoretically more than 100 times greater than that picked up by the conventional style of aerial, operating under identical conditions. There would seem to be no question of the numerous advantages accruing through the general use of the radio beam method of transmission on the part of military, naval and commercial radio telegraph systems; as well as in transoceanic and point-to-point radiotelephony systems where the elements of secrecy and consistent covering of distance without interference are even more important.

As applied to the art of radio broadcasting, the only real advantage of the radio beam system would be in the transmission of programs from a central source to distant points; say, for example, from one country to another, for re-broadcasting by the station through which the greatest number of listeners could be reached. In fact, the utilization of any other type of transmission than that radiating in all directions would defeat the purpose of the broadcasters, whose aim is to cover as much territory and distance as possible with a given power.

The development of the radio beam method of transmission, to the point where it is practically useful, constitutes one of the major contributions to the radio art in several years. Yet the art may be considered to be still in its infancy; for there is much that we do not understand of its puzzling phenomena, the solution of which will result in even greater progress.

Radio in Transoceanic Flight

THE recent flights of Commander Byrd across the Atlantic, and of Lieutenants Maitland and Hegenberger over the North Pacific from Oakland to Hawaii, have marked an epoch in the practical application of radio to aerial navigation. The very deficiencies in the working of the apparatus, reported at length in the press, though at the time they caused apprehension to the flyers and the multitudes on land who waited for news of their success, have been invaluable in their demonstration of the correctness of the principles involved, and the necessity for better facilities to make long-distance aviation as much a matter of routine as steamship travel is today.

A BLAZED AIRWAY

The radio-beacon system, developed by the U. S. Army and now under the special care of the Bureau of Standards, has proved its absolute certainty over the distances covered along routes in the Eastern United States. As explained in the July, 1926, issue of RADIO NEWS, it comprises two stations, one at each end of the flyers' route. At each of these there are two automatic transmitters with aerial systems at right angles to each other; one sending continuously the Morse letter N (dash-dot) the other the letter A (dot-dash). So long as the plane's directional receiver is pointed directly at both, the two signals blend and form a continuous succession of letter Ts (plain dashes). But, should it swing from this course, immediately one letter or the other predominates; and the change of sound advises the pilot to correct his course.

This signal was lost by the flyers a short distance out of San Francisco by a temporary trouble with their receiver; but that at the Hawaiian end was picked up nine hundred miles from the islands, where it indicated correctly a track but three miles wide and was followed to the landing place. Higher power and perhaps reserve receivers will make this system a successful one for long-distance flights between two airports. A refinement of it consists in substituting a visible signal—pilot lights of three colors—for the audible one. A model of this system is one of the sights on exhibition to visitors at the Bureau of Standards in Washington.

The Byrd plane, "America," was equipped with an automatic sending unit flashing continuously its call letters, WTW. This was operated by a small wind-driven turbine on the fuselage. In addition to this, there was the regular manual method of operating the

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